WHAT IS CLAIMED IS:

1. A turbo-code decoder for communication system, the decoder comprising:

a serial-to-parallel output unit, used to receive a serial input signal and output a parallel signal after converting the serial input signal; and

5   a plurality of parallel decoding units, wherein the parallel decoding units are serially connected to form a plurality of levels, the first level parallel decoding unit receives the parallel signal that is output from the serial-to-parallel output unit, the output from the first level parallel decoding unit is sent to the second level parallel decoding unit, with certain sequence, the parallel signal passes through the parallel decoding units for

10   decoding process.

2. The turbo-code decoder of claim 1, wherein each of the parallel decoding unit receives an extrinsic parameter when processing the decoding process, to be the signal that is after the decoding process from the parallel decoding unit, and sends the extrinsic parameter to the next level of the parallel decoding unit.

15   3. The turbo-code decoder of claim 2, wherein the extrinsic parameter is obtained from a deinterleaving operation, the extrinsic parameter of the first level parallel decoding unit is $L_{a0,k}=(0,0...,0)$, where k=1, 2, ..., N, N is the block length of the turbo-code.

4. The turbo-code decoder of claim 1, wherein the serial input signal are $r_{1s,k}$, $r_{1p,k}$,

20   and $r_{2p,k}$ messages of the turbo-code, whereas k=1, 2, ..., N, N is the block length of the turbo-code.

5. The turbo-code decoder of claim 4, wherein the serial-to-parallel output unit receives the $r_{1s,k}$, $r_{1p,k}$, and $r_{2p,k}$, wherein the subscript K=0, 1, ..., N+M-1 represents the whole block and an end message, wherein M stands for a total number of latch units of

the turbo-code decoder, the serial-to-parallel output unit coverts the received $r_{1s,k}$, $r_{1p,k}$, and $r_{2p,k}$ messages and outputs results to the first level parallel decoding unit in parallel, the first level parallel decoding unit also receives an extrinsic parameter $L_{a,k}$ at the same time, the parameter $L_{a,k}$ is obtained via a deinterleaving operation on the previous level extrinsic parameter $\Lambda(d_k)$, the initial value of the first level decoding unit extrinsic parameter is set as $L_{a0,k}=(0,0\ldots,0)$, a first level extrinsic parameter $L_{a1,k}$ is generated via the first level parallel decoding unit, and the message $r_{1s,k}$, $r_{1p,k}$ and $r_{2p,k}$ pass through sequentially to be the input of the next level.

6. The turbo-code decoder of claim 5, wherein the parallel decoding unit comprises:

a first decoder, used to receive the $r_{1s,k}$, $r_{1p,k}$ messages and the extrinsic parameter $L_{a,k}$;

a second decoder, used to receive the $r_{2p,k}$ message and the extrinsic parameter $L_{a,k}$;

an interleaving unit, located between the first decoder and the second decoder, used to receive the output of the first decoder; and

a deinterleaving unit, used to connected to the second decoder, alternately outputs the output of the first decoder and the second decoder.

7. The turbo-code decoder of claim 6, wherein the first decoder of the parallel decoding units constitutes a systolic array very large scaled integrated (VLSI) circuits structure.

8. The turbo-code decoder of claim 7, wherein the systolic array VLSI circuits is composed of N+M units of the module C, A, B, D, and E, wherein,

the module C receives $L_{a1,k}$, $r_{1s,k}$ and $r_{1p,k}$, and outputs $\gamma_k^{(1)}(m',m)$ and $\gamma_k^{(0)}(m',m)$,

the module A calculates a forward recursive probability parameter α_k,

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the module B calculates a backward recursive probability parameter β_k,

the module D adopts (N+M) units of parallel calculation to obtain the $\Lambda(d_k)$ after

the calculation of the α_k, β_k, and $\gamma_k^{(i)}$ are finished, and

the module E outputs the value of the calculation from the module D, where K=1,

2,..., N+M.

9. The turbo-code decoder of claim 8, wherein the value of the $\Lambda(d_k)$ is

calculated according to a MAP algorithm and following equation:

$$\Lambda(d_k) = \log \frac{\sum_m \sum_{m'} \gamma_k^{(1)}(m',m) \cdot \alpha_{k-1}(m') \cdot \beta_k(m)}{\sum_m \sum_{m'} \gamma_k^{(0)}(m',m) \cdot \alpha_{k-1}(m') \cdot \beta_k(m)},$$

wherein α_k is the forward recursive probability parameter, β_k is the backward

recursive probability parameter, $\gamma_k^{(i)}$ is a branch probability parameter.

10. The turbo-code decoder of claim 9, wherein the forward recursive probability

parameter α_k is obtained from the calculation of the previous parameter $\alpha_{k-1}(m)$ and the

branch probability parameter $\gamma_k^{(i)}$, the equation is as follows:

$$\alpha_k(m) = \frac{\sum_{m'} \sum_{i=0}^{1} \gamma_k^{(i)}(m',m) \cdot \alpha_{k-1}(m')}{\sum_m \sum_{m'} \sum_{i=0}^{1} \gamma_k^{(i)}(m',m) \cdot \alpha_{k-1}(m')}$$

11. The turbo-code decoder of claim 9, wherein the backward recursive

probability parameter β_k is obtained from the calculation of the next parameter β_{k+1} and

the branch probability parameter $\gamma_{k+1}^{(i)}$, the equation is as follows:

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$$\beta_k(m) = \frac{\displaystyle\sum_{m'}\sum_{i=0}^{1}\gamma_{k+1}^{(i)}(m',m)\cdot\beta_{k+1}(m')}{\displaystyle\sum_{m}\sum_{m'}\sum_{i=0}^{1}\gamma_{k+1}^{(i)}(m',m)\cdot\beta_{k+1}(m')}$$

12. The turbo-code decoder of claim 9, wherein the branch probability parameter $\gamma_k^{(i)}$ is obtained from following equation according to the MAP algorithm:

$$\gamma_k^{(i)}(m',m) = p(\gamma_{1s,k}\,|\,d_k=i,s_k=m,s_{k-1}=m')\cdot p(r_{1s,k}\,|\,d_k=i,s_k=m,s_{k-1}=m')\cdot$$
$$q(d_k=i\,|\,s_k=m,s_{k-1}=m')\cdot \Pr\{s_k=m\,|\,s_{k-1}=m'\}$$

wherein whether the probability parameter $q(d_k=i\,|\,s_k=m,s_{k-1}=m')$ is 0 or 1

depends on the input bit $d_k=i$ is 0 or 1 combines the probability of the state m' to the

state m.

13. The turbo-code decoder of claim 11, wherein, assuming in a AWGN channel,

the probability is calculated as follows:

$$p(r_{1s,k}\,|\,d_k=i,s_k=m,s_{k-1}=m') = \frac{1}{\sqrt{2\pi}\sigma_{r1s}}\exp\left[\frac{-(r_{1s,k}-\mu_{r1s})^2}{2\sigma_{r1s}^2}\right]$$

$$p(r_{1p,k}\,|\,d_k=i,s_k=m,s_{k-1}=m') = \frac{1}{\sqrt{2\pi}\sigma_{r1p}}\exp\left[\frac{-(r_{1p,k}-\mu_{r1p}(m',m))^2}{2\sigma_{r1p}^2}\right] \quad ,$$

wherein μ_{r1s} and $\mu_{r1p}(m',m)$ is the expectation value of r_{1s} and r_{1p} respectively,

thereinto, μ_{r1s} depends on the input bit, and $\mu_{r1p}(m',m)$ depends on the input bit and also

impacted by the previous state and current state, $\mu(m)$ and σ_{r1p}^2 is the variant of the r_{1s} and

r_{1p} respectively.

14. The turbo-code decoder of claim 12, wherein, assuming that the variant of r_{1s}

and r_{1p} are the same, therefore, the above two equations can be multiplied and

consolidated as follows:

$$p(r_{1s,k} \mid d_k = i, s_k = m, s_{k-1} = m') \cdot p(r_{1p,k} \mid d_k = i, s_k = m, s_{k-1} = m')$$

$$= \frac{1}{2\pi\sigma^2} \exp\left[\frac{-1}{2} \cdot \frac{(r_{1s,k} - \mu_{r1s})^2 + (r_{1p,k} - \mu_{r1p}(m',m))^2}{\sigma^2}\right]$$

15. The turbo-code decoder of claim 11, wherein assuming for a discrete memory-less gauss channel, the branch probability parameter $\gamma_k^{(1)}$ or $\gamma_k^{(0)}$ for input bit being 1 or 0 can be calculated from the equation as follows:

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$$\gamma_k^{(1)}(m',m) = \frac{1}{2\pi\sigma^2} \exp\left[\frac{-1}{2} \cdot \frac{(r_{1s,k} - 1)^2 + (r_{1p,k} - \mu_{r1p}(m',m))^2}{\sigma^2}\right] \bullet \frac{e^{L(d_k)}}{1 + e^{L(d_k)}}$$

$$\gamma_k^{(0)}(m',m) = \frac{1}{2\pi\sigma^2} \exp\left[\frac{-1}{2} \cdot \frac{(r_{1s,k} + 1)^2 + (r_{1p,k} - \mu_{r1p}(m',m))^2}{\sigma^2}\right] \bullet \frac{1}{1 + e^{L(d_k)}}$$

16. The turbo-code decoder of claim 5, wherein the N=4 and the register size M=3, the simplified modules, a data stream, and a latch structure are shown as the content of FIG. 6.

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17. The turbo-code decoder of claim 5, wherein the a priori probability of the input bit d_k calculated by the previous level parallel decoding unit can be used by the next level decoder.

18. The turbo-code decoder of claim 5, wherein $L(d_k)$ is the log likelihood ratio (LLR) extrinsic parameter calculated from the message bit d_k by the previous level

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decoder.